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EVALUATION OF SAFEGUARDS AT THE CYANIDE LEACH OPERATION RICO, COLORADO

for

Crystal Oil Company
P. O. Box 1101
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June 11, 1975

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TABLE OF CONTENTS

INTRODUCTION

Rico Argentine Mining Co., a subsidiary of Crystal Oil Company, commenced operation of a dilute cyanide leach extraction of silver and gold from a 77,000 ton ore heap in July, 1974. On August 11, 1974, there was a relatively sudden release of some dilute cyanide solution at a point on the west face of the heap. As nearly as can be determined, between 3,000 and 5,000 gallons of cyanide solution ran into the Dolores River which is about 100 feet or less from the heap face at the point of the breakout. An unknown quantity of escaping solution was contained and diverted by the then-existing moat without any adverse effect.

The immediate result of the solution spill was to kill a number of fish, both game fish and trash type, for some distance downstream from Rico. By use of an empirical evaluation, the Colorado Division of Wildlife determined the value of the estimated numbers of fish types killed to be $4,576.43.

Apparently no pollution of the Cortez or Dolores water treatment plants occurred; however, Cortez and Montezuma County officials expressed concern about what might have happened, and the mayor of Cortez, on September 16, 1974, addressed a strongly worded letter to the Environmental Protection Agency.

Following the accident in August, Rico Argentine Mining Co. undertook some structural changes to the west side of the heap, raised the outside berm of the moat on the west and north sides of the heap and extended the 40-mil Hypalon heap liner to reach the crest of the new berm.

Crystal Oil Company requested Hazen Research, Inc. to make an independent appraisal of the adequacy of the facilities to prevent or to contain any blowout of cyanide solution in the future. Accordingly, Frank A. Seeton and John S. Holland visited Rico on November 7 and 8, 1974, to inspect the operation. A number of recommendations were offered to improve the safety of the then-existing operation and suggestions were offered for construction and content of future leach heaps.

Crystal Oil Company prepared a report dated May 1, 1975, on its plan for spill prevention, control, and countermeasures. Messrs. Seeton and Holland revisited Rico June 4, 1975, to review the plan and to observe the changes in the operation. Much of the information on which this report is based was supplied by Mr. Orval L. Jahnke, General Manager of the Rico operation.

SUMMARY

The experience of the unexpected release of cyanide solution from the leach heap in August, 1974, the resultant fish kill downstream in the Dolores River, and the adverse public reaction in downstream communities led the Rico Argentine Mining Co. to make several substantial changes within, and immediately adjacent to, the leach heap. The modifications consisted of excavating a drain slot inside the west side of the heap, and the building of a higher berm on the north and west sides of the heap to give the moat much greater capacity to accommodate a blowout.

Leaching operations were shut down for the winter from December, 1974, through April, 1975. During this period, test work on the process and a review of operating methods have led to a number of changes which are now in use or in preparation.

Changes include the decrease in cyanide leach solution strength from three pounds to 1.5 pounds NaCN per ton of solution, diversion of the main river channel to a line about 100 feet west of the river bank adjacent to the west face of the heap, additional rip-rap along the river bank, better lighting around the plant and heap areas, frequent inspections at regular intervals around the clock. The major change is a plan to limit heap thickness to four feet for each course together with changes in heap construction to provide better drainage and thus avoid a buildup of solution within the heap such as occurred and caused the blowout.

There will be continuing apprehension in the downriver area about the possibility of another spill, and some liklihood of continuing hostility from several sources. In view of Rico Argentine's expectation to treat

all or most of the dump material,which has a recoverable gross value of over $4 million or more at the present silver price, provisions must be made to prevent or to contain any possible cyanide contamination of the Dolores River, and thereby avoid or diminish the possibility of litigation or actions which would interrupt the operations.

We believe that the potential hazards have been recognized,and that the safety and control measures now in operation, and the proposed changes in heap structure, if implemented as outlined in Crystal Oil Company S.P.C.C. report of May 1, 1975, are adequate to provide for a continuing safe operation.

RICO HEAP LEACH OPERATION

SOURCE AND NATURE OF ORE

The Rico leach heap in 1974 consisted of about 77,000 tons of mine dump material from the Newman Hill area, much of it coming from the Syndicate dump. The larger dumps in this area were surveyed and sampled about 20 years ago. Screen analyses showed that 30% to 40% of the dump material was minus 1/2-inch and this fraction contained most of the mineral value. The dump material being excavated in October, 1973, contained some fine limonitic material and manganese oxides. The bulk of the dumps consists of vein quartz and sedimentary country rocks including shale, limestone, argillite, and sandstone.

Feed to the heap was regularly sampled and it is said to contain about three ounces silver per ton and a little gold.

It was intended that all material going to the heap would be crushed to minus 1/2-inch. Approximately two-thirds to three-quarters of the material in the heap was crushed to that size; the final portion was material as received from the dump.

ORIGINAL HEAP CONSTRUCTION

The heap was built on a graded surface which slopes to the southeast. The highest point of the base is at the northwest corner, some six feet higher than the southeast corner, from which point the leach solution is drained.

The heap is roughly rectangular in outline, approximately 300 feet by 600 feet at the base,and is 12 to 15 feet thick. It was placed on an impervious membrane of 40-mil Hyaplon. This membrane extends outward from the base of the heap to the crest of the berm at the outer edge of the base surface and thus provides a lined ditch or moat surrounding the heap.

The heap was built by bulldozing the crushed material outward from a fixed discharge point of the belt conveyor. This was considered to result in less compaction than would be produced by truck haulage or use of bowl scrapers or similar wheeled vehicles. A buildup by radial growth from a single point would tend to develop a vague horizontal stratification as material pushed over a bank tends to segregate as the coarser material runs to the bottom of the slope and the fines stay closer to the spill point. Thus, in general the lower portion of a heap so constructed would be expected to have coarser material in the basal portion.

The top of the heap is essentially flat and it is divided into a number of irregularly shaped shallow lagoons by means of dikes. At first the leach solution was applied by rainbird-type sprinklers. Later a flooding procedure was utilized and the lagoons maintain a steady supply of leach solution on much of the top of the heap.

FUTURE HEAP CONSTRUCTION

The existing thick heap has presented several operating problems in addition to the blowout of August, 1974. Variation in permeability has resulted in development of channels through the heap allowing some of the leach solution to pass through quickly and not attack the gold and silver much beyond the channel. As a result, the pregnant solution coming from the heap has a low metal content and parts of the heap are not being leached.

Work is under way (June, 1975) to extend the heap area to the north of the present heap. The new heap will have a maximum ore thickness of four feet and will be made of rock from the original heap as it is being cut down to an ultimate thickness of about four feet. A portion of the new heap will include some freshly crushed dump rock.

The new heap, which is a continuation of the present heap, is to be built on a smooth graded base surface covered with 40-mil Hypalon. Covering the Hypalon will be 9 to 12 inches of coarse screened gravel. The rounded gravel will protect the Hypalon film from puncture damage by angular particles of dump rock. It will also provide a channel for easy lateral flow of the pregnant leach solution outward to the lateral ditch which conveys the solution to the collection pond.

It is planned to have the river (west) side of the heap covered with a facing of coarse gravel which will inhibit and divert downward any strong flow out of the face of the leached heap. With only four feet of rock being subject to leaching, there is no opportunity to develop a hydrostatic head sufficient to cause a "blowout."

The base on which the heap will be placed will slope to the south and east, away from the river, as was the case with the original heap.

Along the west face of the new heap there will be a Hypalon-lined berm as a continuation of the berm built along the west and south sides of the first heap. The top of the berm is four to six feet above the base of the heap. The moat so formed is 12 to 15 feet wide, giving it a capacity to channel a large volume of liquid, as much as 30,000 gallons per 100 feet of length.

METALLURGICAL PRACTICE

Solution containing about 1.5 pounds of NaCN per ton and kept at pH 10.5 with lime is pumped to the top surface of the heap into a number of shallow pond areas occupying the essentially flat top side of the heap. During the 1974 season the solution contained about three pounds NaCN per ton; however, test work during the winter showed that the more dilute solution achieved equal extraction.

The pregnant solution flows from the southeast corner of the heap into a nearby Hypalon-lined pond which has a capacity of about 270,000 gallons. From here it is pumped to the nearby treatment plant for conventional zinc dust precipitation.

The initial design was to circulate 250 gallons per minute (gpm) of the barren cyanide leach solution to the heap. Solution penetration rate declined substantially during 1974 and at the time of our visit in November, 1974, was at a rate of about 130 gpm. The flow ranges from 120 to 180 gpm.

The relatively low percolation rate is the result of several physical and chemical conditions including

1. Presence of excessive fines. The natural clay content and altered mineral fines in the ore heap have a marked effect in diminishing the rate of percolation. Impervious layers of slime-like material are formed which can seal off the solution and cause channeling.

2. Chemical precipitates. Although exact details are not available, aluminum dust precipitation of cyanide-caustic soda solutions was employed initially for a short time. This procedure forms sodium aluminate as a reaction product. The residual sodium aluminate in the heap may have precipitated as insoluble calcium aluminate in the presence of lime when the system was converted to a lime-cyanide leach with zinc dust precipitation. If this occurred, the calcium aluminate precipitate would decrease the permeability of the heap. Other compounds, such as calcium sulfate, could also form and have the same effect.

These problems are expected to be avoided in the heap being built and in future heaps. There will still be a significant quantity of fine material in the heaps because of the nature of the dumps,and the fact that much of the future ore supply will have been screened and crushed. However, there will be less tendency for chemical precipitates to form in the process now used. Lime will be introduced as milk of lime rather than in dry form thus there should be less chance of forming lime crusts. The thinner heaps will permit frequent probing of the solution lagoons on the heap surface to maintain a regular flow into the heap. This will inhibit stagnant solution within the heap and improve extraction efficiency.

SAFETY PRECAUTIONS

After the solution breakout occurred, the berm along the west side of the heap, the side nearest the river, was raised to provide a moat or channel about four feet deep and 15 feet wide, thus providing much greater capacity to contain any sudden flow of solution. In addition, the berm on the north side of the heap was raised to a height of two feet.

A slot about 13 to 15 feet wide and to within four feet of the base was excavated along the west side of the heap just inside the edge. The slot was filled with coarse ore,thereby forming a by-pass or a very permeable channel to divert any sudden surge of solution originating from within the pile. In addition, the west face of the pile was covered with coarse ore to strengthen that side and to provide for diffusion of liquid in the event that a sudden flow exceeded the capacity of the rock-filled slot.

As noted previously, the wide Hypalon-lined moat will be continued along the west face of the new heap,and the heap itself will have a coarse gravel facing on its west side.

An overflow of the moat along the south side of the pile would flow into a dry, calcine-filled impoundment area. The calcine is primarily hematite (Fe_2O_3), and is the residue from the sulphuric acid plant. It probably contains some unburned iron pyrite (FeS_2) and iron salts which would react readily with the solution to destroy the NaCN. The low point of this pond area is at the point where a pipe carrying St. Louis Tunnel drainage water discharges into a series of settling ponds. This series of ponds extends for about one-half mile to the south and parallel to the river before the clear outflow joins the Dolores River. In the event of a spill from the south end of the heap or an overflow of the moat, the dry pond and the water settling ponds would provide a large catchment area and the possibility of sufficient retention time to permit oxidation or complexing of the diluted cyanide solution.

Immediately to the north of the heap are four large steel tanks which were part of the acid plant. These tanks are 50 feet in diameter and 28 feet high and could hold over 400,000 gallons each. A plastic pipeline has been installed whereby solutions from the collection pond or from the barren solution pond can be diverted to a tank using a 650-gpm capacity pump. One tank is now in use to store excess solution resulting from the melting of snow and ice on and around the heap.

It is our opinion that the catchment area around the heap is now adequate to contain any foreseeable leakage that might occur from the north and west sides of the heap. The drain slot in the heap and the coarse rock on the west face would not be conducive to the formation of impermeable areas which would lead to a buildup of a hydrostatic head and a consequent blowout such as was experienced.

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WATER SAMPLE DATA

During the visit to Rico in November, 1974, water samples were collected at five selected points for cyanide determination, and a sample of the St. Louis Tunnel discharge was collected for a partial analysis.

Sample Number	Free Cyanide	Total Cyanide
"A"	less than 10 ppb*	less than 10 ppb
"B"	less than 10 ppb	less than 10 ppb
"C"	less than 10 ppb	less than 10 ppb
"D"	less than 10 ppb	less than 10 ppb
"F"	less than 10 ppb	less than 10 ppb

The 1962 U.S. Public Health Service Standards for drinking water suggest a limit of 0.01 mg/l (ppm) cyanide that should not be exceeded[1/].

	pH	Fe	$SO_4^{=}$	Na	Mg	Ca
"E"	7.4	11.9 ppm**	692 ppm	13 ppm	22 ppm	264 ppm

*ppb = parts per billion or μg/l. **ppm = parts per million or mg/l.

1/ Taras, Michael J., Editor, 1971 "Standard Methods for the Examination of Water and Wastewater," 13th Edition. American Public Health Ass'n, Washington, D.C., p. 33.

"A" is Dolores River water at point 1.95 miles north of highway bridge at Rico, or about 1.3 miles upstream of leach pad.

"B" is Dolores River water at point about 300 feet upstream of the highway bridge at Rico, or about 0.5 mile downstream from the leach pad.

"C" is Dolores River water at highway bridge, short distance downstream from settling pond discharge.

"D" is settling pond discharge about 100 feet above its confluence with Dolores River.

"F" is Dolores River water at U.S.G.S. stream gaging station 0916500 at Montelores Bridge, about four miles southwest (downstream) of Rico.

"E" is water discharged at the portal of St. Louis Tunnel.

RECOMMENDATIONS

Our earlier recommendations included a suggestion that heaps be limited to a six-foot thickness and have a gravel base. The planned four-foot thickness on a gravel base more than meets this suggestion.

It was also suggested that crushing be eliminated and consideration be given to screening out the fines for alternative metallurgical treatment. It is recognized that much of the metal value is in the finer material. The presence of fines in the heaps will not contribute to an environmental or safety hazard in the operation, but alternative handling along the lines recommended might have an economic advantage and could be worth some study.

Better outdoor lighting, inspection of the heap and ponds at regular intervals, and a plan for prompt notification of competent authorities in the downstream areas were recommended. Some mercury vapor light fixtures have been installed and others are scheduled for the area of the new heap. According to the S.P.C.C. plan report, a program of regular inspections is in force and a plan to alert local management and downstream areas has been prepared.

It was recommended that there should be some means of destroying any cyanide in water reaching the settling ponds which clarify the St. Louis Tunnel drainage. We are advised that a supply of hydrogen peroxide is available for addition to the river water downstream from any spill going into the pond system. A supply of potassium permanganate is also available. Both chemicals would be efficient oxidizing agents; however, the use of potassium permanganate could result in an undesirable discoloration of the river water for a short distance.

A program of routine chemical analysis monitoring for cyanide of the Dolores River and all other water courses which might contain drainage from the heap area was recommended. This would detect any minor leaks which might develop around a heap. Continuous monitoring is not necessary but sampling at a few selected sites at intervals of one or two weeks would provide adequate control to detect any minor leakage.

CONCLUSIONS

It is our belief that the limitation of the heap to a thickness of about four feet and provision of a porous base course of coarse gravel are the most effective means of preventing the accumulation of a volume of solution sufficient to cause a blowout such as that of August, 1974. An additional safety factor is provided by the wide, deep berm along the west side of the heap having a capacity to contain a large volume of liquid. The veneer of coarse gravel along the west face of the heap would be effective to dissipate any violent release of solution. As soon as the original heap has been cut down to the planned thickness of about four feet, the heap area can be considered as being safe from any damaging blowout-type spill.

Of importance also is a more acute awareness of the need for inspection and monitoring of percolation rates and condition of the heaps.

The organization plan for containment of a spill,damage repair, neutralization of cyanide solution, and alert of downstream communities is excellent. The plan for Spill Procedures from the S.P.C.C. Plan report is included in this report as an appendix.

Diversion of the main channel of the river to the west side of the river bed and the installation of rip rap along the east bank throughout the length of the heaps will protect the heaps against erosion by any flood that might reasonably be expected.

Other natural hazards are earthquakes and slides. The hillside adjacent to the plant site does not show scars of landslides or snowslides. The published geological map[1/] of the Rico area shows no known or inferred faults in the plant area so the seismic hazard potential is considered to be negligible.

1/ U.S.G.S., 1969 "Geologic Map of the Rico Quadrangle, Dolores and Montezuma Counties, Colorado." GQ-797.

In conclusion, we are of the opinion that the changes and improvements made and underway as of June 4, 1975, will, if carried to conclusion as set forth in the S.P.C.C. Plan, provide an operation that will be as safe for the Dolores River community as good engineering practice and prudent judgment can provide.

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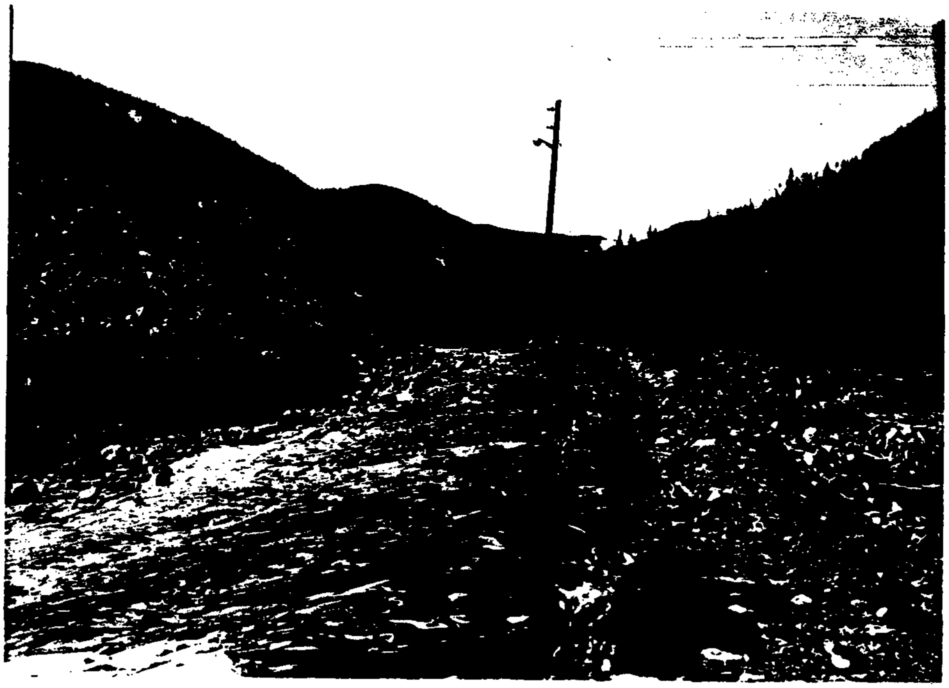
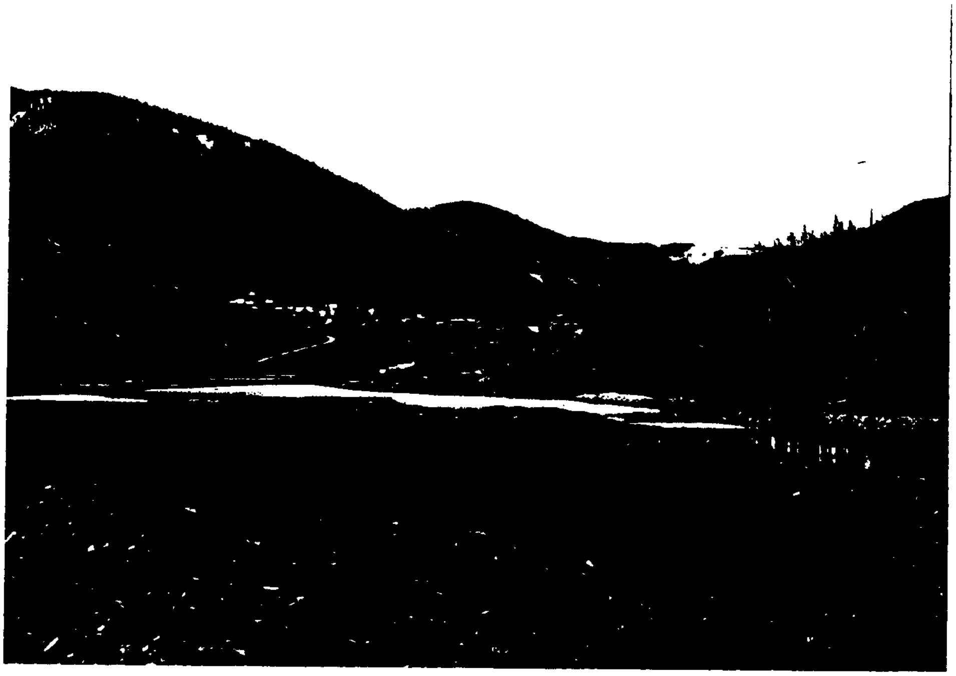


Downstream view of Hypalon-lined moat on west side of leach heap. Note light fixture on pole.

Face of berm and rip rap on west side of heap area. Spring runoff is causing heavy flow in Dolores River. Peak flow at the time, June 4, 1975, was recorded at 1,580 cfs (711,000 gpm) at the gage below Rico. Maximum daily rate in 1972 was 660 cfs, in 1973, 1,620 cfs, and in 1974, 783 cfs.

Hypalon sheet being laid for the base of the new heap to be constructed.

Hypalon strips being "welded." Application of heat from the electric blower produces a superior bonding.



Downstream view of calcine pond in foreground and the string of clarification ponds containing St. Louis Tunnel effluent. Ponds are separated from the river by the levee in the background.

Southeast corner of heap showing emergence of pregnant leach solution from the heap and the collection ditch. Calcine pond in background.

APPENDIX

Excerpts from

RICO-ARGENTINE
MINING COMPANY

SPILL PREVENTION, CONTROL
AND
COUNTERMEASURES PLAN

May 1, 1975

SPILL PROCEDURES

I. Orval Jahnke is in full charge of all operations during a spill. In his absence Melvin Pack and/or C. E. Towne is in charge.

II. The employee or person finding the spill will notify the plant operator and Orval Jahnke.

III. The spill should

A. Go into the hypalon tanks

1. Set up to pump spilled solution into the 400,000 gallon tanks.

B. In case of an excessive overflow that the pumps could not handle, solution will overflow the hypalon tanks into the calcine ponds.

1. The calcine ponds extend south over 1/2 mile before entering the river. The ponds will neutralize the solution before it enters the river.

2. Mel Pack or Orval Jahnke will test water from the ponds where it enters the river or just above Rico.

3. The two barrels of Hydrogen peroxide will be taken to the Rico bridge or a point in the river ahead of the spill. Peroxide will be sprayed on the water as the spilled solution flows by. Employees handling Hydrogen Peroxide are to wear soft side goggles and 12" or longer plastic or rubber gloves.

IV. Mary Jahnke will call downstream communities and tell them what happened, what we are doing about it and recommend that they shut any water intakes from the Dolores River.

A. Rico Water Dept. 967-2474
or
Mayor Curran 967-2584

B. Dolores Water Dept. 882-7720
or
Police Dept. 882-4656
Dolores County Health Dept. 565-3056

C. Cortez Water Dept. 565-9824
or
Police Dept. 565-3784

Montezuma Co. Health Dept. 565-3056

D. State of Colorado Dept. of Health (303) 388-6111, ext. 231
(After hours) (303) 366-5363

E. U. S. Environmental Protection Agency (303) 837-3880

F. Fred Hinman (Colo. Dept. Health, Montrose) 249-3431

G. Tom High (State Mine Inspector) 243-6318

V. The supervisor in charge will dispatch an employee to warn campers downstream.

VI. The damage will be repaired.

VII. Tests will continue to be made at various points downstream as far as necessary until all readings are below the allowable limit of .01 mg/1 (ppm) cyanide.

VIII. Those communities that were notified of the spill will be called and told that tests show there is no further danger.

XI. The cause of the spill will be studied and preventive measures undertaken.